History

- Drawbacks of using file systems (cont.)
  - Atomicity of updates
    - Failures may leave database in an inconsistent state with partial updates carried out
    - Example: Transfer of funds from one account to another should either complete or not happen at all
  - Concurrent access by multiple users
    - Concurrent access needed for performance
    - Uncontrolled concurrent accesses can lead to inconsistencies
      - Example: Two people reading a balance and updating it at the same time
  - Security problems
    - Hard to provide user access to some, but not all, data
- Database systems offer solutions to all the above problems

Levels of Abstraction

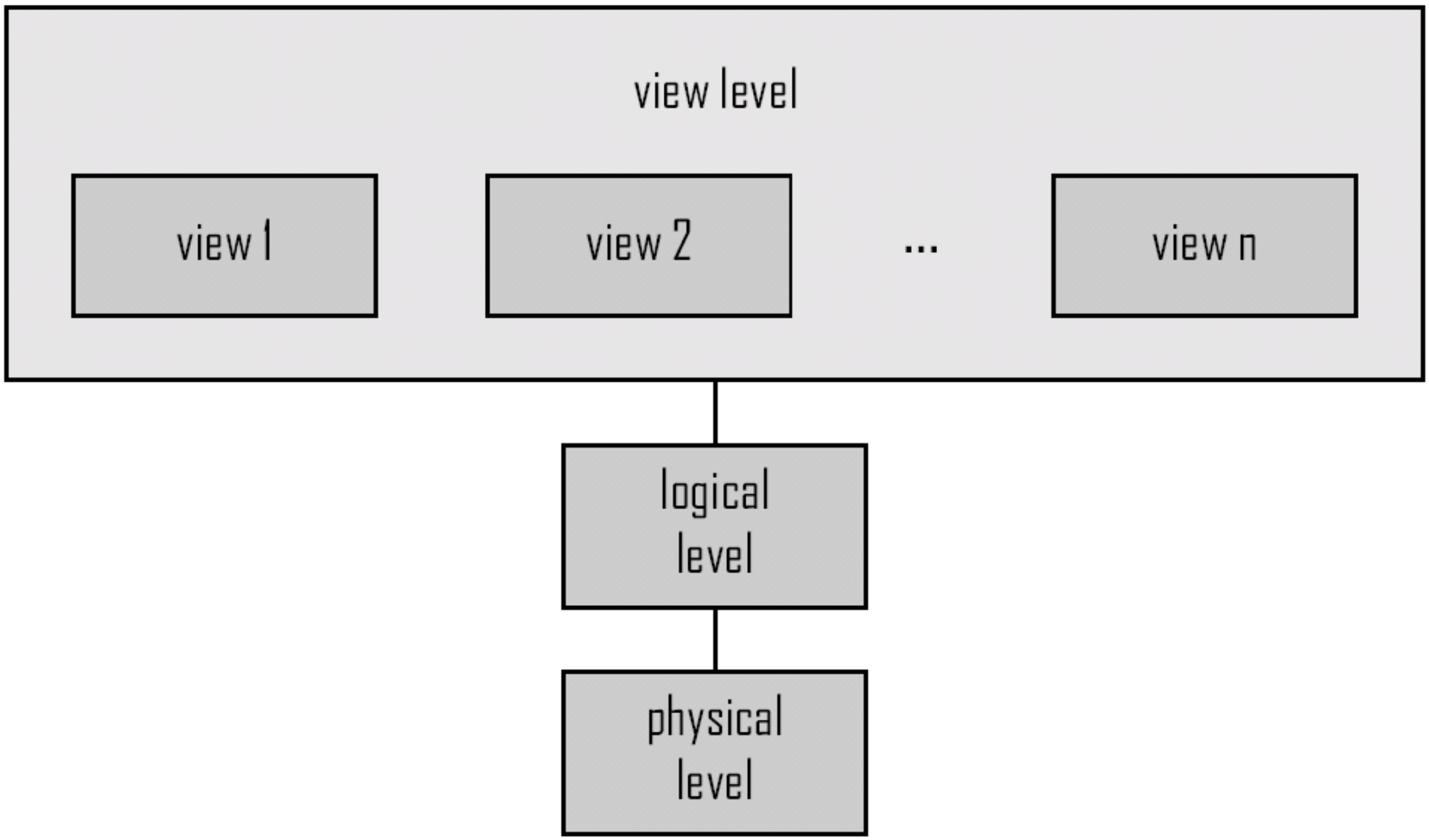
- **Physical level**: describes how a record is stored.
    - data structures used; byte level strorage
- **Logical level**: describes the data stored in database, and the relationships among the data.
- lowest level at which programmers and admin interact with database

```
type customer = record

    customer_id : string;
    customer_name : string;
    customer_street : string;
    customer_city : integer;

end;
```

- **View level**: application programs hide details of data types. Views can also hide information (such as an employee's salary) for security purposes.

View of Data

An architecture for a database system



Schemas and Instances

- Similar to types and variables in programming languages
- Schema – the logical structure of the database (at every level) ; rarely changes
  - E.g.: DB consists of information for set of customers, accounts, & their relationships
  - Analogous to type information of a variable in a program
  - **Physical schema**: database design at the physical level
  - **Logical schema**: database design at the logical level; most important
  - **View schemas** (*subschemas*)
- Instance – the actual content of the database at a particular point in time
  - Analogous to the value of a variable
- Physical Data Independence – the ability to modify the physical schema without changing the logical schema
  - Applications depend on the logical schema
  - interfaces between various levels should be well defined so that changes in some parts do not seriously influence others.

Data Models

- A collection of conceptual tools for describing
    - Data
    - Data relationships
    - Data semantics
    - Data constraints
- Relational model
    - tables; most widely used
- Entity-Relationship data model (mainly for database design)
- Object-based data models (Object-oriented and Object-relational)
- Semistructured data model (XML)
- Other older models:
    - Network model
    - Hierarchical model

Data Manipulation Language (DML)

- Language for accessing and manipulating the data organized by the appropriate data model
  - Retrieval, insertion, deletion, modification
  - **Query**: statement in DML requesting information
  - DML also known as query language (technically incorrect)
- SQL is the most widely used query language
- Two classes of languages
  - Procedural – user specifies what data is required and how to get those data
  - Declarative (nonprocedural) – user specifies what data is required without specifying how to get those data
- Abstraction: DML => physical level algorithms
  - ease of use

Data Definition Language (DDL)

- For defining the database schema
  - Example: **create table** account (
    account-number char(10),
    balance integer)
- Integrity constraints
  - **Domain** constraints (integer, character, date)
  - **Referential** integrity (referenced values across relations)
  - **Assertions** (always valid condition)
    - “every user with loan must have >$1000 balance”
  - **Authorization** (read, insert, modify, delete)
- DDL compiler generates output: a set of tables stored in a **data dictionary**
- Data dictionary (table) contains **metadata** (i.e., data about data)
  - Database schema
  - DD consuted before reading/modifying data